



## **Mathematics Teachers' Explorations of Indigenous Mathematical Knowledge Systems through Immersion in African Cultures**

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### **Abstract**

A handful of research has shown the importance of integrating cultural practices that resonate with students' ethnic and background experiences in everyday instruction. Particularly in teacher education courses, there has been an unprecedented focus on valorizing the use of community-based, culturally-oriented learning experiences in light of the diverse demographics that thrive in schools today. Notwithstanding the extensive literature that urged the utilization of cultural immersion experiences as means of increasing cultural sensitivity for students across disciplines, little effort has been documented about the usefulness of immersion for teaching culturally-responsive mathematics. The purpose of this research is to document initial, firsthand field experiences of graduate mathematics education students while engaged in exploring indigenous knowledge systems by immersion in the daily experiences of indigenous cultures in Morocco and South Africa.

**Keywords:** Indigenous Knowledge Systems; Immersion; Mathematics Education

## Introduction

Indigenous knowledge (IK) is generally used anonymously with traditional and local knowledge to differentiate the knowledge developed by and within distinctive indigenous communities from the international knowledge systems generated through universities (Semali & Kincheloe, 1999), government research centers, and private industry which is sometimes called the 'Western knowledge system' (Maurial, 1999). Furthermore, Indigenous Knowledge Systems (IKS) have been recently established by the international world organizations as top global priority for empowering traditional and local communities in their striving efforts towards improved and sustainable development, particularly in developing countries (Shizha & Kapoor, 2010). However, despite its highly proclaimed importance and sound pedigree of recognition for strengthening native communities' preservation of social and traditional capitals towards more independence (Chahine & Kinuthia, in press), no clear effort has been cited that magnifies and exposes the contributions of indigenous cultures to the mainstream knowledge and epistemologies.

For many years, there has been a longstanding history of marginalizing and de-valoring the contributions of indigenous communities to the edifice of scientific knowledge (Chahine, 2011; Chahine, 2013). When we come to consider the nature of mathematical knowledge and who produces this knowledge we enter an ambiguous realm of philosophical conjecturing. This historical reduction is partly due to a rather limited view of what counts as mathematics on one hand and to a lack of understanding of living indigenous practices on the other. We know very little, or nothing at all, about what it means to be part of an indigenous community historically and contemporarily. We contend that re-inscribing a narrow understanding about indigenous practices into our collective views of mathematical knowledge mutes, and at worst, silences deeper discussions about what mathematics are we teaching in our increasingly diverse classrooms and how we are teaching it.

This study capitalizes on the role that IKS play in cognitive development and their vital contributions to successful and meaningful learning of mathematics in conventional and nonconventional contexts. In this study, we argue that immersing teachers in indigenous cultures will acquaint them with a broad perspective on indigenous knowledge systems and structures, which cover a plethora of contents and contexts that incorporate mathematical artifices. These structures include indigenous music, architecture, mural decorations, indigenous games, bead work, weaving, cultural artifacts, and other social systems and activities.

The study is part of a newly designed course uniquely offered at an urban, highly diverse university in the southeast. The course particularly focuses on teaching *Indigenous Mathematical Knowledge Systems* (IMKS) through cultural immersion in indigenous contexts. The primary purpose of the course is to examine how different cultural groups interpret mathematical concepts in ways that are quite different from what we might expect from typical mathematical texts. This instructional experience dovetails two components:

**Component 1:** Class work (Location: on campus). In this component, students and in-service teachers investigate mathematical ideas inherent in activities such as creating calendars, art and decoration, divination, and counting schemes. Connections between IMKS and mathematics education in schools are also emphasized.

**Component 2:** Cultural immersion (Location(s): South Africa; Morocco). This component affords firsthand field experiences to explore IMKS by immersing students in the authentic daily experiences of master craftsmen and knowledge holders of vital indigenous technologies. During the site visit, students explore the integration of hand and mind tools that indigenous cultures continually employ to plan, conceptualize, visualize and execute myriad activities as part of their daily practice.

To motivate critical thinking, we employed various educational modalities in the on-campus portion of the course including: cubing, small group inquiries, whole-group discussion, problem-based investigations and tiered assignments. For the immersion component, students engage in participative forms of inquiry investigating ideas that transpire in out-of-school settings. Throughout the course students are encouraged to experiment with innovative ideas, to make their experimental thinking public, and to develop new epistemologies that guide the teaching and learning of nonconventional mathematics. Students' effort was evaluated based on the intellectual merit of their research projects, the investigative procedures they developed during field work, validity of their claims, and communicability of their research accounts.

### **Purpose of the Study**

This study examines graduate students and mathematic teachers' reflections on an immersion experience that facilitated first-hand observation of the mathematical ideas that emerge across indigenous cultures as creative expressions of human thought. The primary goal of this immersion was to offer students a transcultural experience where they can experience the realities of knowing and doing mathematics amidst contextual challenges. Immersion through studying abroad as a college program is an area where some meaningful, but limited, research has been published. While the particular focus of studying abroad as a program that facilitates language acquisition and gains in functional international knowledge has been researched, limited investigations have been attempted to explore the effect of immersion on learners' perception of the nature of indigenous mathematical knowledge. A critical implication of being immersed in indigenous practices is to sensitize students to the delicacies of what it means to be part of a different cultural fabric, leading to their appreciation of various modes of thinking across cultural boundaries.

### **Theoretical Frameworks**

The instructional experience is principled by two frameworks: the *Embodied, Situated, and Distributed* (hereafter ESDC) approaches to the study of how the mind works (Chahine & Kinuthia, in press), and Activity Theory (AT) framework.

The basic tenet underlying ESDC paradigm is the view that cognition is physiologically embodied, socio-culturally situated, and ostensibly distributed among individuals (Anderson, 2008). These approaches atypically emphasize the notion that the brain and, consequently, the mind and its processing cognitive faculties are continuously developing as a result of perpetual interaction with the physical and social world (Reichelt & Rossmanith, 2008). A significant connotation of this paradigm is the view that the brain is no longer isolated from the body, the environment, and the culture of individuals; instead, it constitutes, alongside with the immediate environment, one unitary integrated system. Concomitantly, it is only through the use of one's

sensory motor activities as a result of being situated and immersed in specific worlds that one is able to form inferences and think abstractly.

Drawing from evidence in studies using the ESDC paradigm, a basic premise underlying our assumption for guiding students' learning during immersion in nonconventional settings is the belief that cognitive processes are stimulated when students are immersed in multimodal experiences using successive cycles of integrated actions and perceptions (Gallese & Lakoff, 2005). An important implication of the embodied cognition framework on applied problem solving is the significant role that different modalities (i.e., bodily movement, use of cultural artifacts, acts of drawing pictorial displays, verbal language as well as use of written symbols) play in understanding mathematical concepts. Throughout the course, understanding of new mathematical concepts that emerge in cultural contexts is reinforced by encouraging students' construction of *cognitive metaphors* while immersed in perceptual-motor acts of indigenous people (Lakoff & Núñez, 2000).

Using the ESDC paradigm, our charge in the immersion experience is to provide evidence supporting the embeddedness of thinking-in-acting model as a fundamental framework that explains and supports students' learning. Specifically, the range of research studies that the students report at the completion of the course provide evidence of the role that multiple modalities and translations within and between modalities play in enhancing students' procurement and understanding of the mathematical concepts and problem solving strategies that indigenous people employ in their daily practice.

The study is also guided by the AT paradigm. Activity Theory (AT) has at its core the *subject-tool-object* triad built off of Lev Vygotsky's (1978) expansion of the basic stimulus-response relation fundamental to behaviorist models of psychology. However, Leont'ev (1978, 1979) developed first-generation Activity Theory that refined the meanings and relationships of the components of the triad shown in Figure 1. For Leont'ev the meaning of subject was broadened to give more attention to a *collective subject* – a group of individuals acting upon a common object. This concern for the collective subject means that Leont'ev explored more complex *activity*, where different actors need to engage in separate *actions* in order to transform the object into the desired outcome of the activity. The efforts of all individuals are directed towards such transformations, but in order to address the differences between the individual and the group forms of such efforts, Leont'ev distinguished three levels of efforts. At the highest level, there is the group activity, in which the transformation of the object into the outcome is driven by the over-arching group *motive*; at the intermediate level, this transformation is directed towards the attainment of an individual's *goal* (which may or may not contribute directly to achieving the motive); and at the lowest level, there are subconscious *operations* which are influenced by the *conditions* under which the activity takes place and can contribute to realizing goals and motives.

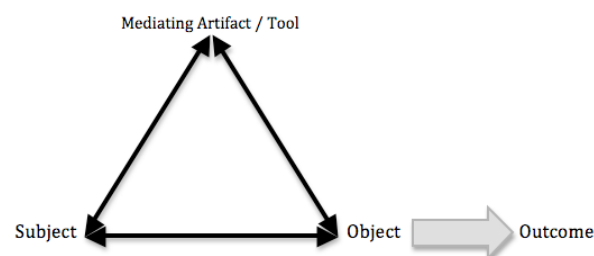


Figure 1. The Triad of 1<sup>st</sup>-Generation Activity Theory.

AT framework is guided by the belief that thinking and doing are inseparable –a central assertion of AT which assumes that our knowledge of the world is mediated by our interaction with it, and thus, human behavior and thinking occur within meaningful contexts as people conduct purposeful goal-directed activities (Nardi, 1997). Using AT framework, we focus on the premise that subjects, i.e., IK holders and teachers acting in different contexts, i.e. community and schools, both create and represent their intentions and desires as objects (note that the term also denotes an objective), while the tools (consisting of both concepts and artifacts) used in this process mediate between both groups and their goals (Kaptelinin, 2006). Activity theorists (Stetsenko, 2005) suggest that knowledge is socially-situated or context bound because social interactions are fundamental and inseparable from the development of ways to think, understand, or mediate mental activity. This perspective aligns with IKS epistemology and suggests that careful attention must be given to the context in which the development of understanding of teaching occurs, and learning must be situated in a context like the one in which these understandings will be used.

Within an AT framework, we study the activity comprising those actions undertaken by IK holders and teachers while interacting with different tools which they normally use in their respective work environments, i.e. community and schools. Specifically, we investigate how immersion in cooperative activities during immersion can motivate IK holders and teachers to engage in knowledge production that ultimately informs their objectives to serve their community and schools. Simply put, AT afforded a rich description of activity systems that emerge as products of the intentions of IK holders and teachers while employing different tools to mediate their activities and reach their objectives. Since AT strongly advocates socially organized human activity as the major unit of analysis, we believe that AT is best capable of capturing the totality of the activities of indigenous knowledge holders and teachers while interacting during professional development. During the study, we draw on the relationship between these elements (tools, subject, and object) as our participants engage in a set of activities, actions and operations undertaken during immersion.

## **Methodology**

### **Research methods and data collection**

We conducted a qualitative study that focused on 14 graduate students and mathematics teachers who participated in a one-semester course on IMKS that included a highly integrated immersion experience ( i.e., students living with host families) in Morocco and South Africa. Accompanied by the researcher as the immersion director and course facilitator, students were continuously encouraged to explore and rely on the authentic host culture for their daily living.

Prior to immersion, students attended 4-week long classes on campus in which they were introduced to IMKS as a program of study and they further explored the implications of integrating such a program in the school curriculum. Students were engage in an assortment of in-class activities that include examination of the mathematical ideas that come from cultural activities such as creating calendars, art and decoration, divination, and counting schemes.

Orientation and preparation for the immersion component of the course and on-site activities was also administered.

During immersion, students were assigned to different sites and were specifically encouraged to particularly focus during their observations on capturing those nuances in which indigenous communities are involved in a process of “mathematizing”. Students were also asked to keep a daily journal to document and reflect on their lived experiences as a result of immersion. After immersion, students completed a critical reflection paper describing their immersion experiences and comparing their newly gained knowledge and perceptions as a result of immersion to preconceived notions and dispositions before the immersion.

### **Analysis and Results**

The analysis of the findings of this study does not focus on outcomes such as improved test scores, but rather on the lessons, conflicts and stories that were created along the way and that impacts students' conceptualization of the nature of mathematical knowledge from an IKS perspective. We employed the AT subject-tool-object triad for coding the data for analysis. We believe that at the junction of the three lies the learning that came from processes, interface content, attitude shifts.

We conducted the data analysis on several levels:

- 1) Students' initial reactions to the immersion experiences and their appreciation of transcultural encounters.
- 2) Students' learning as a result of being involved in indigenous practices and the consequent impact on their cognitive, affective and socio-cultural norms.
- 3) Students' willingness to transfer what they learned as a result of immersion to their mathematics classrooms.

### **Two communities and two activity systems**

#### ***Graduate students and mathematics teachers***

As members of school community, our students who are mathematics teachers perceived the immersion as a way to explore new means to enact some change in their practices and the activity system within which they are embedded to better support student understanding of mathematics. They perceive of students as the object of their activity and student learning the outcome being sought. The primary artifacts that mediate teachers' student-oriented activity include curricular resources such as unit and lesson plans, instructional media, and technologies (Suthers, Yukawa, & Harada, 2007).

#### ***IK holders and practitioners***

IK holders and practitioners are community members and elders that are holders of traditional knowledge and resources that are transmitted orally (stories and explanations) (Chahine & Kinuthia, in press). As members of local communities, practitioners and IK holders apply their indigenous practices in everyday activities to facilitate problem solving of day-to-day issues. The

object of their activity systems is survival and adaptation to continuously evolving situations. As such, communities are in a constant learning mode appropriating variety of artifacts including hand and mind tools to understand the world around them. Such tools are typically the results of generations of observation, trial, and experimentation.

During immersion IK holders and math teachers interact with each other exchanging ideas to create and represent their goal directed activities using tools to mediate their goals. We argue that during immersion a collaborative partnership between IKS holders and teachers helped to motivate, inform and empower both parties to address priorities related to their activities.

### **Discussion**

Investigating the impact of using indigenous techniques and practices to investigate relevant concepts in the mathematics classroom is an emerging research interest. Ample research has shown the importance of integrating cultural practices that resonate with students' ethnic and background experiences in everyday instruction (Jurdak & Shahin, 1999, 2002; Chahine, 2011, 2013; Ascher, 2002; Presmeg, 2007; Noss, Hoyles, & Pozzi, 2000). Furthermore, extensive research has urged the utilization of cultural immersion experiences as means of increasing cultural sensitivity for students across disciplines. Particularly in teacher education, the value of using community-based learning has been heightened in light of the diverse demographics that thrive in schools today. In mathematics education, the yet unseen value of immersion experiences transpires inadvertently when participants consciously view, actively participate, and reflect upon how other cultures use and develop their own mathematics to respond and make sense of their world.

Building on AT paradigm we sought to understand how much the immersion experience upset students' existing equilibria, requiring fresh adaptation toward a higher developmental level. Using the AT paradigm, our charge in this study is to provide evidence supporting the embeddedness of a thinking-in-acting model as a fundamental framework that explains and supports students' learning. Specifically, the range of research studies that the students report at the completion of the course provided evidence of the role that immersion played in enhancing students' procurement and understanding of the mathematical concepts and problem solving strategies that indigenous people employ in their daily practice.

The study produced interesting results on the scale measuring development in ways of thinking and learning. Usually in our teacher preparation courses, we see students typically progress from a simple, more absolute understanding of the nature of knowledge and academic authority to a more complex and contextual understanding. We found that students who participated in the immersion experience showed growth toward the belief that developing one's own point of view is important, and that it is important to seek an interdisciplinary approach to knowledge. Additionally, we noticed that students returned home with a reduced tendency toward dualistic thinking and an inclination toward the related belief that there are no absolute right and wrong answers, good and bad information, as well as sources thereof.

Overall, students felt that the immersion experience enriched them culturally, linguistically, academically, and personally. The perspectives students gained on the nature of mathematical

thinking were considered useful in informing their future instructional decisions and the range of experiences they offer their students.

Experiencing IMKS through cultural immersion emphasized the importance of unfolding various knowledge systems inherent in the cultural practices of indigenous communities. We argue that this immersion experience afforded an intellectual landscape for students to:

- Develop an awareness of and appreciation for IKS as a well-founded research model delineating those cross generational endeavours aimed at investigating and understanding the physical world. As such, the immersion experience afforded students the opportunities to explore a broader conceptualization of what counts as mathematics.
- Examine research areas in mathematics education that integrate race, ethnicity, social class, and language issues. By observing IK holders, students experienced upfront the unfolding of those culturally embedded mathematical competences which empower communities and grant them opportunities for survival and self-development.
- Instigate and facilitate in their classrooms multiple, malleable approaches to teaching and learning mathematics as a result of being exposed to mathematical practices that are in continuous flux and which emerge as a result of the dynamics of the work context.
- Use real world problems as opportunities for reflective thinking. By exploring mathematics via tasks which come from the workplace and everyday settings, students were able to discern the relevance of mathematical concepts and are more likely to teach it in ways that are meaningful. Students discerned that the value of using workplace and everyday tasks for teaching mathematics lies in its potential to shield learners from falling into the trap of focusing on the procedures at the expense of concepts.
- Honor diversity and respect cultural heritages thus promoting the belief that all people are capable of doing mathematics in their own unique and personal perspective. A direct implication of this study is to encourage teachers to be mindful of the fact that children from diverse backgrounds have different modes of thinking, possess diverse perceptual abilities and spend differential efforts on tasks depending on personal criteria which they deem useful.

We believe that immersion in indigenous practices has capacitated our in-service mathematics teachers to achieve quality in practice-based research by developing living theories that can explain the transformational potentials of mathematical thought for sustainable local and global wellbeing.

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